

**IMAGING OF ANATOMY OF THE LOWER EXTREMITY  
WITH CLINICAL EXAMPLES  
MSI GROSS ANATOMY-2003**

**L.G. Shapeero, M.D.  
Chief, Musculoskeletal Radiology  
Uniformed Services University**

**ANATOMY of the MUSCULOSKELETAL SYSTEM**

**Bones  
Cartilage  
Soft Tissues  
Muscles  
Ligaments  
Tendons  
Arteries, Veins, Nerves  
Subcutaneous Tissues**

**IMAGING TESTS**

**Radiography  
Scintigraphy (Bone Scans)  
Sonography (Ultrasonography, US)  
Computed Tomography (CT)  
Magnetic Resonance Imaging (MRI)**

**ABCD'S CRITERIA for  
IMAGING MUSCULOSKELETAL ANATOMY**

**Alignment, Age of patient  
Bone Density  
Contour  
Distribution?  
Soft tissue, Sex**

**The student should use these criteria for evaluating normal  
and abnormal anatomy on imaging studies.**

**RADIOGRAPHIC DENSITY**

<b><u>Appearance on Radiograph</u></b>	<b><u>Why</u></b>
<b>Normal cortical bone appears white</b>	<b>Bone absorbs x-rays</b>
<b>Blood appears lighter gray than normal soft tissues</b>	<b>Blood absorbs more x-rays than soft tissues (e.g. muscle)</b>
<b>Normal soft tissues appear gray</b>	<b>Soft tissues partially absorb x-rays</b>
<b>Normal fat appears dark gray</b>	<b>Fat absorbs less x-rays than other soft tissue (e.g. muscle)</b>
<b>Air appears black</b>	<b>Air does not absorb x-rays</b>

## **HIP and THIGH**

**Bones, Joints**

**Muscles**

**Subcutaneous Tissue**

**Nerves, Arteries, Veins**

### **CLINICAL EXAMPLES:**

**A patient presented with pain in the region of the right hip.**

**Hip pain may result from multiple causes.**

#### **I. Fracture as a cause of hip pain**

**On the radiograph, where is the fracture of the hip anatomically located? Femur? Acetabulum?**

##### ***Teaching Points***

1. In proximal femoral fractures, the location is important.
2. Fractures in the proximal femur located above the intertrochanteric region can lacerate the lateral circumflex femoral artery that supplies the femoral head.
3. This can result in death (necrosis) of the femoral head

**Does the fracture extend into the hip joint or knee joint? What is the alignment and contour? What is the *distribution* of fractures? Is there more than one fracture present?**

##### ***Teaching Point***

*CT* can be used to show the exact number and relationship between fracture fragments and to show extension into the adjacent joint. This information is useful for planning for surgical fixation of fragments.

**What is the *bone density*?**

##### ***Teaching Point***

Bones that have decreased bone density (e.g. osteoporosis) may be weakened and more likely to fracture. This particularly occurs in elderly patients, especially women.

#### **II. Arthritis as a cause of hip pain**

**Is the hip joint narrowed?**

##### ***Teaching Points***

*Radiographs* can show joint space narrowing. The *distribution* of the narrowing helps determine the kind of the arthritis:

- a. Longstanding arthritis causes "wear and tear" and thinning of the cartilage (osteoarthritis-degenerative arthritis), and the hip joint is often narrowed, *particularly superiorly*.
- b. Inflammatory arthritis (e.g. rheumatoid arthritis), usually causes circumferential narrowing of the joint most severe in the *center* of the acetabulum (axial narrowing).

##### ***Teaching Point***

1. When patients have long-standing hip arthritis and persistent severe pain, they may receive a hip prosthesis for pain relief.
2. Radiographs show the *anatomic* relationships between the prosthesis and the surrounding acetabulum and femur (also applicable to knee prostheses).

### III. Tumor as a cause of hip pain

**On the radiographs, where is the tumor located? Does the tumor originate in the bone (medullary canal, the cortex, or periosteum} or in the soft tissue?**

**Teaching Point:**

Location of the tumor is important for treatment and for longterm survival.

For example, patients with tumor located in the periosteum usually require less extensive surgery and may not need chemotherapy. Also, patients with periosteal tumors often live longer than patients with other types of tumors.

**What is the contour of the tumor? Is it well-defined or poorly defined?**

**Teaching Points**

1. *Well-defined* tumors, more likely *benign*.
2. *Poorly-marginated* tumors with destruction of trabeculae, usually *malignant*.

**Does the poorly marginated tumor invade the surrounding structures (the muscles, nerves, arteries, and veins)?**

**Teaching Points**

1. This information is essential for adequate resection by the surgeon and is best shown on *MRI*.
2. Patients may complain of numbness or tingling in the region of a tumor  
MRI will define the invasion of the tumor into adjacent nerves.  
*E.g.* a tumor in the adductor magnus invades posteriorly into sciatic nerve.

**For bone tumors, is there more than one bone involved?**

**Teaching Points**

1. When tumors are found in multiple bones (e.g. femur, ischium, ilium, pubis, sacrum), the patient usually has metastases.
2. *Metastases* are tumors that go from one organ through the blood or lymphatic circulation to seed other sites (bone, lungs, brain, liver, etc). *Bone scans* are used to show the *distribution* of these metastases throughout the skeleton.
3. Metastases usually occur in the medullary canal in the shaft (diaphysis) of a bone and not commonly in the ends (epiphysis) of the bone.

**What is the bone density in the tumor?**

**Teaching Points**

1. Metastases that cause poorly-marginated areas of *increased* bone density frequently originate from the prostate in men and from breast in women
2. Metastases that cause poorly-marginated areas of *decreased* bone density can originate from many different organs in men and women.(e.g. lung, thyroid gland, kidney)

## **KNEE and LEG**

### **Bones, Joints**

### **Muscles**

### **Menisci**

**Ligaments and Tendons (Anterior Cruciate Ligament , Posterior Cruciate Ligament , Medial Collateral Ligament, Lateral Collateral Ligament, Biceps Tendon, Iliotibial Band, Patellar Ligament, Quadriceps Tendon)**

### **Subcutaneous Soft Tissue**

### **Arteries, Veins, Nerves**

### **CLINICAL EXAMPLES:**

**I. A 19 year-old man developed acute swelling of the knee after falling while downhill skiing. Is a fracture present?**

***Teaching point***

As with the hip and thigh, the bones on the radiographs should be evaluated for abnormal *alignment, bone density and contour* of the bones.

**Does the fracture extend into the knee joint? Is there a knee effusion?**

***Teaching points***

The suprapatellar bursa communicates with the knee joint and may extend above and behind the patella when distended with fluid. The radiographic density of the fluid helps determine its composition. Effusion=tissue density    Blood=denser than tissue

**Are the tendons and ligaments and menisci torn?**

***Teaching points***

1. Severe twisting injuries of the knee can cause tears of the menisci or tears of the anterior and posterior cruciate ligaments, the medial (tibial) and lateral (fibular) collateral ligaments, and biceps tendon and tears of the muscles (quadriceps tendon, popliteus tendon/muscle).
2. *MRI* is the most useful imaging test for evaluating the menisci and soft tissues (ligaments, tendons, muscles). *MRI* determines the exact site of tear, the length of tear and associated fractures of bone.

**II. A 25-year-old woman developed acute knee pain while playing tennis.**

***Teaching Points***

1. Radiographs show a bony defect of the lateral part of the medial condyle consistent with an *osteochondral* fracture. However, the cartilage cannot be evaluated on the radiographs because it is usually not calcified..
2. *MRI* is the best test for showing the cartilage and can show both the cartilaginous and bony fracture defects.

**III. A 38 year-old man developed numbness and tingling in the region of the extensors and peroneal muscles in the distribution of the peroneal nerve after falling off a horse onto his flexed right leg.**

***Teaching points***

1. The peroneal nerve passes posterior to the fibular head and may be compressed by a dislocation or fracture of the fibular head.
2. *Radiographs* can show the fracture or dislocation of the fibular head
3. *MRI* can show the compression of the nerve by the fracture or dislocation.

**IV. A 48 year-old woman had tenderness and swelling of the calf**

**Is there a thrombus (clot) in the deep veins of the leg?**

***Teaching Points***

1. A cause of this swelling is thrombosis of the deep veins of the leg.
2. *Sonography* with color flow Doppler can show flow in veins and arteries (normal, increased, decreased or absent flow) and can demonstrate the thrombi in vessels.

**Is there an injury to the muscles or tendons?**

***Teaching Point***

1. A cause of acute calf pain in a patient, who was intensely exercising, is a tear of the muscles particularly, in the posterior compartment (gastrocnemius and soleus)
2. *Sonography* or *MRI* can show the muscle involved and the exact point of the tear.

## FOOT and ANKLE

### Bones, Joints, Muscles

**Tendons and Ligaments (Peroneal Tendons, Achilles Tendon, Flexor Tendons, Extensor Tendons, Deltoid Ligament, Anterior and Posterior Talofibular Ligaments and Calcaneofibular Ligament )**

### Subcutaneous Soft Tissue

### Arteries, Veins, Nerves

## CLINICAL EXAMPLES

### **I. A 45-year-old woman developed sudden onset of pain after jumping to make a basket while playing basketball with her son. She cannot not stand on her toes.**

**What do the soft tissues show?**

#### ***Teaching Points***

1. *Radiographs* show that the fat anterior to the Achilles tendon has been obliterated.
2. *MRI* shows a complete tear of the Achilles tendon with disruption of the normal *contour* and obliteration of the fat anterior to the Achilles tendon due to post-traumatic inflammation/blood .

### **II. The 63-year-old woman presented with a flat foot.**

***Is there normal alignment of the bones on the radiographs? What is the contour of the posterior tibial tendon?***

#### ***Teaching Points***

1. *Radiographs* show that the longitudinal arch of the foot is flattened.
2. *MRI* shows a tear of the posterior tibial tendon with abnormal *contour* as the cause of the flat foot. The posterior tibial tendon inserts into the tibial tuberosity of the navicular, and also into the medial, middle and lateral cuneiforms and the plantar surfaces of the second to fourth metatarsals. An intact posterior tibial tendon helps maintain the longitudinal arch of the foot.

### **III. A patient presents with painful swelling of the foot.**

**Does the patient have an infection causing the inflammation?**

***On the radiographs, what is the bone density ? On MRI, what is the distribution of the infection in the bones and soft tissues?***

#### ***Teaching Points***

1. In early infection, *radiographs* may show soft tissue swelling and decreased *bone density* (osteoporosis). Radiographs initially do not show the marrow infection (osteomyelitis).
2. To institute effective therapy, osteomyelitis should be recognized early and *MRI* , easily shows the changes of osteomyelitis of the marrow and extension of the infection into the soft tissues (subcutaneous tissues, muscle, and tendons) and the formation of abscesses.

**Does the patient have inflammatory arthritis?**

**What is the *age* of the patient? What is the *alignment* of the joints?**

**What is the *bone density*? What is the anatomical *distribution* of the arthritis ?**

**Are the *soft tissues* normal? Is the patient a *man* or a *woman*?**

#### ***Teaching Points***

1. In inflammatory arthritis, the inflamed synovium "eats away" the ends of the articulating bone and cause erosions (abnormal *contour*) with loss of cortical bone and joint space narrowing as seen on the radiographs
2. *Abnormalities of alignment, bone density, distribution* of the bone and soft tissues changes, and *age* and *sex* of the patient can help distinguish different types of arthritis.

	<u>Rheumatoid Arthritis</u>	<u>Gout</u>
<b>Age</b>	20-50 years	>50 years
<b>Alignment</b> (Subluxations)	At PIP* and MTP** (1-5)	At 1st MTP
<b>Bone Density:</b>	Decreased (osteoporosis) (particularly around the joints)	Normal
<b>Contour Abnormalities</b>	Erosions of PIP+MTP(1-5), tarsal joints	Erosions of 1st MTP; sometimes tarsal joints
<b>Distribution</b>	PIP and MTP (1-5), tarsal joints	1st MTP; sometimes tarsal joints
<b>Soft Tissue</b>	Swelling of PIP/MTP (1-5) Swelling of tarsal joints Subcutaneous nodules	Tophus of 1st MTP
<b>Sex</b>	Women: men, 2:1	Men:women:, 5:1

\*PIP: proximal interphalangeal joint  
\*\*MTP: metatarsophalangeal joint

### IN SUMMARY:

**Each imaging test has specific uses that help us evaluate normal structures and anatomic abnormalities of the lower extremity.**

<b>RADIOGRAPHY:</b>	<b>for the bones and joints, but remember to look at the soft tissues</b>
<b>SCINTIGRAPHY (BONE SCANS)</b>	<b>for global evaluation of the bones; particularly to show metastases</b>
<b>COMPUTED: TOMOGRAPHY(CT)</b>	<b>for cross-sectional imaging of the bones; e.g. to plan for surgical pinning of a fracture</b>
<b>SONOGRAPHY (US)</b>	<b>for a particular ligament or tendon or muscle</b>
<b>MAGNETIC RESONANCE IMAGING (MRI)</b>	<b>for the bones, joints, and soft tissues</b>